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*MICROSCOPIC SCIENCE.*¹

PROF. T. G. WORMLEY delivered no formal address. He gave only a short discourse, in which he described the advantages and possibilities of two special applications of the microscope: first, to the detection of very minute quantities of certain poisons, notably arsenic, by the examination of the sublimate; second, to the examination of blood stains. He described the limits within which identification of different animals, and the recognition of human blood, is feasible; he denied that human blood can be absolutely identified; he also stated that the result of prolonged experiments indicated that pure water is the best reagent for restoring the blood-corpuscles in a stain to their natural condition.

*MAN IN THE TERTIARIES.*²

IN studying the questions of his own origin and antiquity, man has been hindered by many prejudices and by many barriers of his own erection, the first and most formidable of which was the theological barrier of the Mosaic cosmogony. In process of time this was partially removed; but other barriers to free investigation arose, founded on the evidence collected by the very men who had done most to destroy the earlier obstacles. Cuvier declared that man, being the last and highest of creation, could never have been contemporary with the extinct species of mammals found in the quaternary beds. For a time all evidence to the contrary was treated with contempt; but Cuvier's massive authority was finally overthrown by Perthes, Schmerling, and others.

No sooner had the Cuvierian barrier against quaternary man been demolished, than smaller barriers of precisely the same nature were erected against the tertiaries. Gaudry could not admit that the worked flints discovered by the Abbé Bourgeois in the miocene of Thenay were the remains of men; because he found it difficult to believe, that, while every other species of the miocene is now extinct, man alone should have remained unchanged. Professor Dawkins in a similar line of argument assumes that man cannot be looked for until the lower animals now in existence made their appearance. In the eocene age there were none of the present living genera of placental mammals, in the miocene none of the present living species; and it is most unlikely that man should appear at such a time. At this period the apes (*Simiadae*) haunting the forests of Europe were the most highly organized types. Moreover, if man were upon the earth in the miocene age, it is incredible that he should not have become something else during those long ages in the course of which all the

miocene land mammalia have either assumed new forms or been exterminated. And for similar reasons Professor Dawkins says he cannot expect to find traces of man in the pliocene. But such assumptions are obstructive: they not only put a check upon research, but they prevent the unbiased consideration of fresh evidence.

These theories have been greatly strengthened by the idea that man has been evolved from the higher apes, and that his nearest relations among these creatures are those which are supposed to have appeared last in the sequence. Nevertheless, we find the evidences of man associated with extinct apes, and the gap between them is by no means closed in these earlier horizons. In the earliest remains of man thus far recognized, we do not have the most pronounced ape-like features, as we should have a right to expect if both have sprung from the same stem, and if man is limited to the quaternaries. All these forms are still man, with a fair brain-case; though the slight modifications toward an ape-like structure have the deepest significance in clearly indicating the direction from which he sprang.

If paleontologists are right, the first anthropoid apes have been found in the middle eocene, and later still a more generalized form called *Oreopithecus*; and side by side with these are found chipped flints if we are to accept the authority of their discoverer Bourgeois and the opinion of Mortillet and others. If man existed then, — and on theoretical grounds there is no reason to believe that he did not exist, — we must look much farther back for the approach of these two groups.

The earliest evidences of man must be sought in his remains, and not in his works; but the very conditions of life which characterized early man and his associates render the preservation of their remains a matter of extreme improbability. The herbivora in herds, seeking the shelter of watery places, would in dying become mired, and thus preserved in a matrix for the future explorer. Aquatic forms are infinitely more abundant as fossils than land or aerial forms, — water-birds than land-birds. The arboreal ancestors of man, and the probable habits of man himself, would leave their bones to bleach in the field or forest, to decompose and disappear long before an entombment was possible. It was only when man acquired the art of sepulture, or sought refuge in caves, that the preservation of his remains became assured. Surface changes, however, have been so wide-spread and profound as to nearly obliterate all trace of these places, and when preserved the harvest from them has been of the most meagre description. Of nearly fifty caves examined by Schmerling in Belgium, only two or three contained human remains. Lund, who examined eight hundred caves in Brazil, found only six containing human remains. The grain of the Swiss lake-dwellers, and even the bread they made, have been preserved; but human bones are of scanty occurrence. The Danish peat-beds have as yet yielded none, though stone implements and other objects are found there in abundance.

Chief among the agencies in destroying the evi-

¹ Abstract of an address before the section of histology and microscopy of the American association for the advancement of science, at Philadelphia, Sept. 4, by Prof. T. G. WORMLEY of the University of Pennsylvania, vice-president of the section.

² Abstract of an address to the section of anthropology of the American association for the advancement of science, at Philadelphia, Sept. 4, by Dr. EDWARD S. MORSE, of the Peabody academy of science, Salem, Mass., vice-president of the section.

dences of man have been the glacial floods; and these, if the glacialists are right, have occurred, one during the earlier pliocene and the other at the beginning of the quaternary. In the gradual recedence of the glaciers, no less destructive agencies were at work in scooping out valleys, inundating immense areas, and covering broad tracts of land by their detritus.

It would seem from many facts, that early man lived in the vicinity of water, either on the banks of rivers or along the coast-line; and it is just these regions which have been most profoundly modified since glacial days, and, indeed, in all times.

Saporta suggested the idea that man, originating in the north, had been pushed southward by successive waves of people till the primitive wave was forced into the extremities of the southern continents, and that the remnants of this ancient wave are seen in the Tasmanians, Bushmen, and Fuegians. If so, the remains of primitive man are buried under paleochrystic ice. Far more probable would it be to assume an antarctic continent under genial conditions in which these primitive races lived, and whence successive waves emanated, becoming modified by their new surroundings as they receded from their point of origin. We should then assume the submergence of this region; leaving remnants of these low types in the Patagonians, Tasmanians, Bushmen, and others, and precisely where we might expect to find them. If either supposition is true, the earlier traces of these people are buried beyond recovery. The prejudices of man himself have also caused the loss of much precious material, or of opportunities which can never be regained, — ancient skeletons exhumed only to be promptly buried again; others encountered in excavation, and left undisturbed through superstitious fear. Even at the present time, while the collection and study of the remains of other fossil mammals go on unchallenged, the archeologist is beset by a class who repudiate his facts, look upon his evidences as deceptive or fraudulent, and misunderstand his aims.

From what has been said, it is evident that the discovery of the remains of primitive man is highly improbable. Until this good fortune comes to us, as come it may, we must be content to reason from the known to the unknown. In regard to the physical characteristics of man, there is a manifest disproportion between the changes he may have undergone, and the known change of other mammals since miocene days. For, while slight changes in man's osteological structure have undoubtedly taken place, many mammals of huge form and great variety have become extinct, and others have been profoundly modified. On the other hand, it seems reasonable to believe, that, the moment the ancestors of man possessed the power of banding together in communities, and of using weapons, they became capable of rendering inoperative the very influences which were so active in modifying or exterminating their mammalian associates. How far these conditions were settled in the quaternary, may be seen from the fact, that while man could endure an arctic climate, and survived the glacial period, his anthropoid and more distant pithi-

coid relations disappeared from Europe forever on its approach.

The fact that man, and his near associates, have been regarded as structurally the highest forms of mammals, has led to the natural belief that they must have been last evolved. That man is pre-eminently the highest form intellectually, goes without the saying; but in regard to his physical characteristics it seems that sufficient importance has never been given to the generalizations of Cope, who shows that "the mammals of the lower eocene exhibit a greater percentage of types that walk on the soles of their feet, while the successive periods exhibit an increasing number of those that walk on the toes, while the hoofed animals and carnivora of recent times nearly all have the heel high in the air. . . . Thus, in all generalized points, the limbs of man are those of a primitive type so common in the eocene. His structural superiority consists solely in the complexity and size of the brain. A very important lesson is derived from these and kindred facts. The monkeys were anticipated in the greater fields of the world's activity by more powerful rivals. The ancestors of the ungulates held the fields and the swamps, and the carnivora driven by hunger learned the arts and cruelties of the chase. The weaker ancestors of the quadrumana possessed neither speed, nor weapons of offence or defence; and nothing but an arboreal life was left them when they developed the prehensile powers of the feet. Their digestive system unspecialized, their food various, their life the price of ceaseless vigilance, no wonder that their inquisitiveness and wakefulness were stimulated and developed, which is the condition of progressive intelligence." This explains on rational grounds why man has continued to persist for so long a time with physical characteristics so slightly modified, while other forms were changing or becoming extinct.

It has been shown that structurally he is related not only to the higher apes, but with numerous lower forms, and even with the lemuroids, remains of which have been found in the lower eocene of both continents. If these structural affinities are valid, then we must look far beyond and below the present higher apes for the diverging branches of man's ancestry.

Another evidence of his antiquity is the early establishment of well-marked types, which must have required an enormous lapse of time to have become established. The various types of skulls are met with among the earliest traces of man. In the lake dwellings of Switzerland, Dr. His has discovered four different types of skulls.

Professor Kollman, who has made an extensive study of the crania of both hemispheres, concludes that the sub-species of man became fixed in the pre-glacial period. Furthermore, the evidences go to show that early man had become sufficiently differentiated to acclimate himself to widely different regions of the earth's surface, while the apes are still confined to the torrid zone. The remains of his feasts show that he had early become omnivorous. The most powerful argument in favor of tertiary man lies in the fact that his earliest remains are not confined to

any one region of the earth. The river-drift men are found impartially scattered from tropical India through Europe to North America. If their distribution was by the northern approaches of the continent, it must have been in pre-glacial times, because, as Dawkins shows, an ice-barrier must have spanned the great oceans in northern latitudes.

It seems an almost fruitless speculation, to inquire into the manner of their dispersion, yet one is tempted to surmise that if they originated in the tropics, then submerged continents must again be restored to offer the necessary means for such a dispersal. If, on the other hand, their home was in the north or south temperate zone, and the distribution circumpolar (and this seems more probable), then we have another evidence of the wide separation which the race had acquired, at that early day, from its tropical relatives the apes. Whatever the facts may ultimately show, this unparalleled distribution of a people in the lowest stages of savagery proves beyond question that man must have pre-existed for an immense period of time; for, with the known fixity of low savage tribes, the time required to disperse this people over the whole earth can only be measured by geological centuries.

The farther we penetrate into the past, and ascertain some definite horizon of man's occurrence, other observers in widely different regions of the earth bring to light traces of man's existence in equally low horizons. The evidence of the remoteness of man's existence in time and space is so vast, that, to borrow an astronomical term, no parallax has thus far been established by which we can even faintly approximate the distance of the horizon in which he first appeared. From this fact we are justified in the assumption that the progenitors of quaternary man, under different genera possibly, must be sought for in the tertiaries.

Science will not gain by the erection of any theoretical barriers against tertiary man, until such definite forms are met with that shall reasonably settle the beds in which he first occurred. We know in what rocks it would be obviously absurd to look for his remains or the remains of any mammal. So long, however, as forms are found in the lowest beds of the tertiaries, having the remotest affinity to his order, we must not cease our scrutiny in scanning unbiased even the rocks of this horizon, for traces of that creature who, until within a few short years, was regarded as some six thousand years old, and who, in despite of protest and prejudice, has asserted his claim to an antiquity so great, and a dispersion so profound, that thus far no tendency to a convergence of his earliest traces has been demonstrated.

SCIENTIFIC METHODS AND SCIENTIFIC KNOWLEDGE IN COMMON AFFAIRS.¹

Economic science and statistics can hardly do less than to promote the use of scientific methods, and

¹ Abstract of an address before the section of economic science and statistics of the American association for the advancement of science, at Philadelphia, Sept. 4, by Gen. JOHN EATON, U. S. commissioner of education, Washington, vice-president of the section.

disseminate scientific knowledge in common life. Science has had a hard struggle with ignorance. A host neither small nor amiable has been arrayed against it. What wonder, then, that it has first intrenched itself where the use of instruments of precision and the demonstrations of mathematics separated it from the critical issues of man's every-day conduct? Nevertheless, history may in the remote future express surprise that in America, where the power and conduct of man are so important, science has so long neglected the rugged issues assigned to this section.

There is now no good reason why scientific men should neglect to apply scientific methods to the economy and statistics of every-day life. If mathematical principles and processes are applicable to the statics and dynamics of physics, why not also to the statics and dynamics of society? If useful in economics, why not in personal and domestic life? True, in all questions of conduct, we must include man's free action of will, and leave room for doubt or for alternatives or for contrary choice; yet how many questions of daily life are left to the merest conjecture, to superstition, or to the wild estimatings, and how large a percentage of blunders might be avoided! We smile that a pagan commander moved his army by the flight of a crow or by the aspect of an animal's entrails; but how many merchants sail their ships, and agriculturists plant or harvest, by the guesses of charlatan weather-prophets, or how many actions are determined by seeing the moon over the right shoulder, or by confidence in a horseshoe! Myriads of groundless notions to-day affect the conduct of personal and public affairs. It is time for science to enter. Many a juggler would then lose his business, many a prejudice have to be given up. Pockets, policies, and politics are involved in the issue. The disposition to revel in the marvellous, to dally with uncertainties, and to treat all mystery as concealing the superhuman, would be disturbed. The phrases 'we guess,' 'we reckon,' are giving way to the phrases 'we will inquire,' 'we will try to know.'

Sir William Thompson has said, "Accurate and minute measurement seems to the non-scientific imagination as a less lofty and dignified work than looking for something new;" but he adds, "Nearly all the grandest discoveries of science have been but the rewards of measurement and patient, long-continued labor in the minute shifting of numerical results." Thus the methods of economic science are the same as those of other branches of science, while the latter also yield statistical results.

It is unfortunate that scientific men aspire so exclusively to original research. We need men to couple love of science with love of mankind. Livingstone desired to explore Africa for science, but as much so for the civilization of benighted Africans. Is science for man, or man for science? Is not benefit to mankind the real measure of the good that is in science?

Doubtless Stephenson was more perplexed with the mood of the parliamentary committee than with the questions of improving his steam-engine. From a